PATENT SPECIFICATION (11) 1310254

DRAWINGS ATTACHED

(21) Application No. 31395/70 (22) Filed 29 June 1970

(31) Convention Application No. 9297 (32) Filed 30 June 1969 in

(33) Sweden (SW)

(44) Complete Specification published 14 March 1973

(51) International Classification E21D 13/02

(52) Index at acceptance

E1F 1 6

F1G 1A

F4P 1A1X 1B3 1B5X

G6C 667 696

(54) METHOD OF PREVENTING LEAKAGE DURING STORAGE OF A GAS OR A LIQUID IN A ROCK CHAMBER BY ARTIFICIALLY SUPPLYING A GAS OR A LIQUID TO THE ROCK SURROUNDING THE ROCK CHAMBER AND A SUBSTANTIALLY LEAK-PROOF ROCK-CHAMBER

(71) I, ERIK INGVAR JANELID, a Swedish Subject of Forsetevägen 18, Djursholm, Sweden, do hereby declare the invention for which I pray that a Patent may be granted to me, and the method by which it is to be performed to be particularly described in and by the following statement:—

It is known when storing gas, for example compressed air, or liquid, for example petrol or oil, in a rock chamber where the gas or liquid is in direct contact with the walls of the rock chamber, to prevent leakage through the cracks in the rock by artificially supplying water to the rock surrounding the rock chamber. The water supply should preferably be such that no decrease in the normal ground water level occurs. The supply of water prevents the rock from being drained and since all cracks are filled with water under a higher pressure than in the chamber, the contents of the rock chamber is prevented from leaking out.

The usual way of preparing a rock chamber for storage is first to blast the rock chamber and drill the holes which are to be used for the artificial water supply and start supplying the water when the rock chamber is to be taken into use. However, it has now been found that while the rock chamber is being blasted a considerable drainage takes place in the rock, which may have serious consequences when the rock chamber is taken into use for storing gas or liquid. It has been found that refilling the cracks in the rock with water by means of the natural or artificial supply of water takes a very long time and may be incomplete. Therefore, if the artificial supply of water is initiated at the same time as the rock chamber is taken into use, or a short time before, there may be a risk that not all cracks have time to be filled with water. The hydraulic conditions are therefore insufficient and leakage occurs. If leakage has occurred at one point there is a great risk that the gas or liquid will gradually displace the water from the rock so that the leakage increases. In order to eliminate this risk of leakage it may be necessary to wait a long time before taking the rock chamber into use, i.e. until all cracks have been filled either naturally or artificially, so that the ground water level recovers a certain value and the necessary hydraulic pressure is obtained in the cracks.

However, if the artifical supply of water is carried out in a suitable manner even while the rock chamber is being blasted, the rock around the proposed rock chamber never becomes drained and the rock chamber can be taken into use immediately it is finished. The artificial supply of water, suitably through a series of drill holes near to the proposed rock chamber, increases the flow of water into the rock chamber but this flow of water can be kept within reasonable limits by sealing the rock in the walls of the rock chamber under construction in known manner by means of, for example, concrete injection, and by keeping the water pressure and quantity under control and at a suitable value.

According to a preferred embodiment of the invention the water is supplied to the rock under such a pressure that the water pressure in the rock nearest the rock chamber is higher than the maximum natural ground water pressure which can be achieved, i.e. it corresponds to an imagined ground water level lying higher than the surface of the ground.

The invention thus is principally directed to sealing a rock full of cracks by the artificial supply of water under pressure to the rock. Alternatively, leakage of the contents of the rock chamber can be prevented by supplying a liquid other than water, or possibly a gas, under pressure to the rock.

The invention will now be described with reference to the accompanying drawings. Figs. 1 and 2 show a vertical and a horizontal section, respectively, through a rock chamber construction sealed by the method according to the invention. Figs. 3 and 5 illustrate alternative methods of carrying out the sealing. Fig. 4 is a detail of Fig. 3 on a larger scale. Fig 6 shows how the sealing may be carried out with two different liquids.

Figs. 1 and 2 show a number of rock chambers 1 which communicate through a shaft 2 with a power station 3 in which the electrical generating means are driven by a gas turbine, and through a shaft 4a and a gallery 4b with a lake 5. When excess power is available, this is used to fill the rock chambers 1 with compressed air from a compressor driven by the gas turbine, so that a corresponding quantity of water is forced up through the shaft 4 to the lake 5. When the power station must deliver maximum power, water is allowed into the rock chambers 1 through the shaft 4 and the compressed air passes up through the shaft 2 to the gas turbine so that the normal air compressors need to supply compressed air to the gas turbine not be used.

At a somewhat higher level than the rock chambers 1 a number of horizontal galleries 6 have been blasted. From these several horizontal holes 7 have been drilled, which extend above the rock chambers 1. Water is supplied under pressure through a shaft or drill hole 8 to the galleries 6 and drill holes 7. The water pressure in the drill holes 7, or rather the water pressure in the drill holes 7 plus the hydraulic pressure generated by the level difference N, should be higher than the maximum permissible air pressure in the rock chambers 1.

The galleries 6 and drill holes 7 are prepared before or at the same time as the rock chamber and the water pressure is applied before or at the same time as blasting of the rock chambers 1 is initiated. The galleries 9, 10 are transport tunnels which are plugged when the construction is finished.

In the embodiment according to Fig. 3 and 4 a number of holes 11 have been drilled upwardly in the roof of the rock chamber 1. The drill holes can first be used for injecting the rock and the drilling is then continued to the desired depth, and a tube 12 is inserted in the upper part of the drill hole and the lower part is then sealing with a concrete plug 13. Each tube 12 from the drill holes is connected to a pressure water conduit 14 and in this way a continuous over-pressure is maintained in the rock above the rock chamber 1. It is important that the drill holes 11 are made and the water pressure applied gradually as the rock chamber 1 is under construction. One or more drill holes 11a with pressure water tubes are therefore suitably prepared when the transport gallery 9 is blasted so that no drainage of the rock takes place.

In the embodiment according to fig. 5 several vertical drill holes 15 have been made from the surface of the ground above the proposed rock chamber 1. The drill holes have then been used in the same way as in accordance with Fig. 3, for injecting the rock nearest the ground surface. The drilling has then been continued to the desired depth, a tube 16 inserted in each drill hole and sealed the hole with a concrete plug 17. The tubes 16 are then connected to a pressure-water conduit 18. When the pressurized water has been applied, blasting of the rock chamber 1 is initiated and the rock is therefore kept saturated with water during the entire construction period.

In the embodiments according to Figs. 1—5 the water has been supplied at a higher level than the rock chamber in order to eliminate the risk of leakage upwardly from the rock chamber. Fig. 6 shows how the rock chamber can be screened off on all sides.

In the embodiment according to Fig. 6 the rock chamber 1 is surrounded by a series of inner galleries 20 from which vertical and horizontal drill holes 22 extend, and by a series of outer galleries 21 with drill holes 23. The drill holes form an inner and an outer screen of drill holes around the rock chamber and are supplied with water or some other liquid under pressure through conduits 24, 25.

The idea of having several screens around the rock chamber is that the rock chamber may contain a substance which is not suited to be in direct contact with water, for example. A suitable and effective screening system can thus be obtained, for example for underground nuclear power plants, by arranging first an inner screen containing a different fluid, a liquid or a gas, which separates the rock chamber from, for example, the pressurized water in the outer screen.

In this arrangement it is also feasible for the rock chamber to contain gas or liquid of quite a different temperature from the surrounding rock. If the temperature is extremely low in the rock chamber it is possible, for example, to pump a substance into the inner screen system, which does not freeze at the low temperature, but fills out all cracks around the rock chamber.

WHAT I CLAIM IS:—

1. A method of preventing leakage during storage of a gas or a liquid in a rock chamber by artificially supplying water or other suitable liquid or gaseous fluid to the rock surrounding the rock chamber, characterized in that the water is artificially supplied through a series of drill holes also before or during blasting of the rock chamber.

2. A method according to claim 1, characterized in that at a level higher than that of the proposed rock chamber, a number of substantially horizontal galleries are blasted, a number of substantially horizontal holes then being drilled from these galleries, the galleries

and drill holes then being filled with water and thereafter the rock chamber blasted.

3. A method according to claim 1, characterized in that as the rock chamber is blasted, several substantially vertical holes are drilled in the roof and water is then supplied to these drill holes.

4. A method according to claim 1, characterized in that a number of substantially vertical holes are drilled in the ground surface above the proposed rock chamber, water is supplied to these drill holes and the rock chamber is then blasted.

5. A method according to claim 1, characterized in that a system of galleries and drill holes leading from these is constructed on all sides of the proposed rock chamber, these galleries and drill holes then being filled with water or some other liquid or gaseous fluid, and the rock chamber is then blasted.

6. A method according to claim 5, characterized in that the galleries and drill holes are designed so that they form at least one inner screen and at least one outer screen around the rock chamber.

7. A method of building a rock chamber, comprising drilling a plurality of drill holes in the rock at least above the desired rock chamber, supplying pressurized water to said drill holes so as to maintain the natural ground water level, and subsequently excavating the rock chamber while continuing the supply of pressurized water to said drill holes.

8. A rock chamber including drill holes surrounding the chamber on at least four sides, and means for supplying a pressurized fluid to said drill holes for maintaining the natural ground water level with the drill holes arranged to form an inner curtain and an outer curtain.

9. A method of preventing leakage during storage of a gas or a liquid in a rock chamber by artificially supplying water or other suitable liquid or gaseous fluid to the rock surrounding the rock chamber, substantially as hereinbefore described with reference to the accompanying drawings.

WITHERS & SPOONER,
Chartered Patent Agents,
148—150, High Holborn,
London, E.C.1.,
Agents for the Applicant.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1973.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

Fig.1

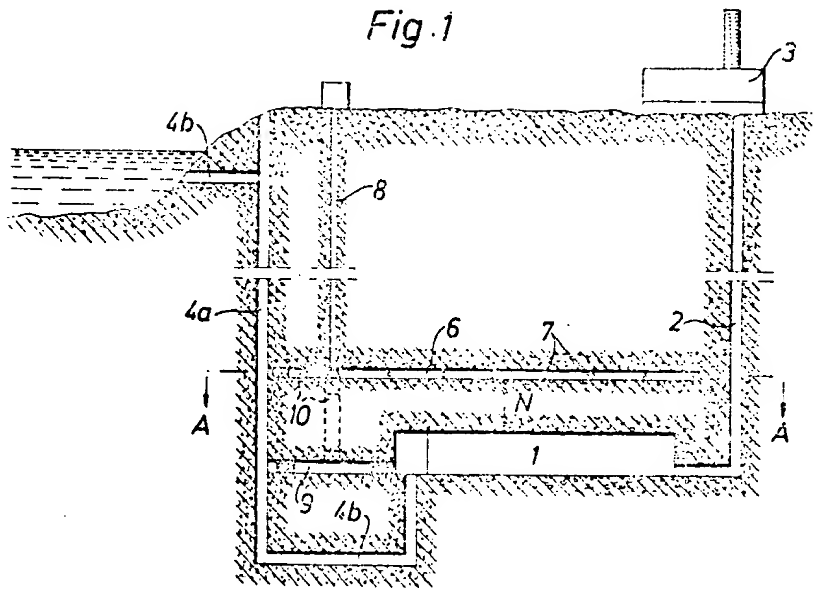

Fig.2

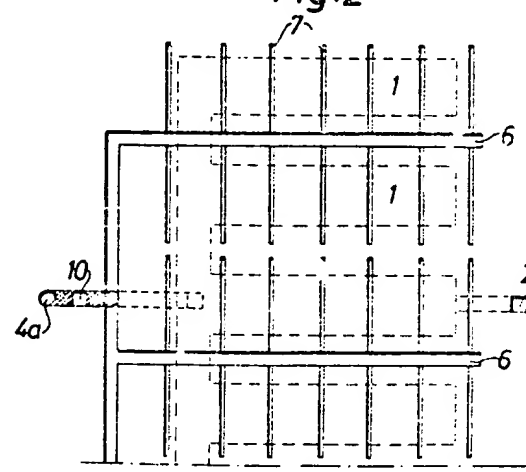

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Fig.3

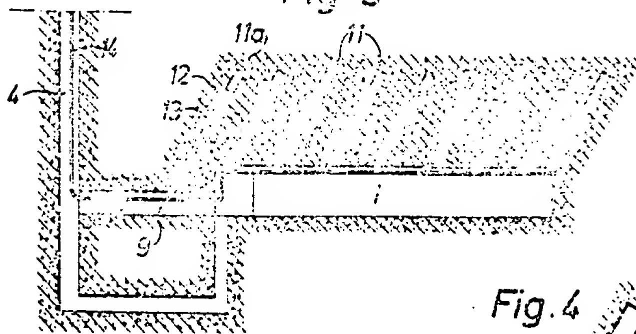

Fig.4

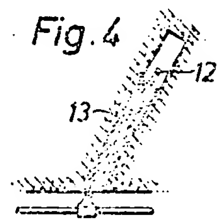

Fig.5

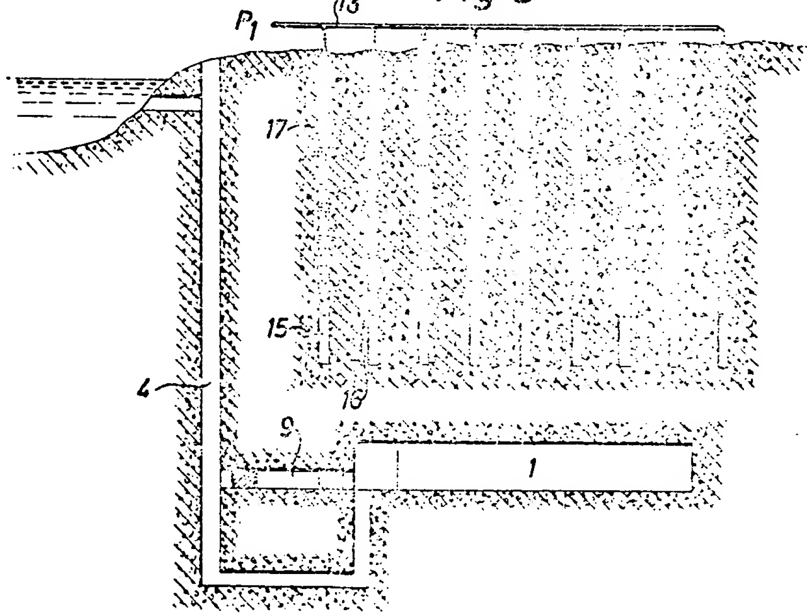

Fig. 6